

Proposal for Flags and Masks

Aquarius Project Document: **AQ-014-PS-0006**

3 June 2014

Version 3.0



Proposal for Flags and Masks

PREPARED BY (CUSTODIAN):

David M. Le Vine and Thomas Meissner

Name

Date

APPROVED BY:

Gary Lagerloef

Name

Date

Name

Date

Name

Date

DOCUMENT CHANGE LOG

Change Number	Change Date	Pages Affected	Changes/ Notes	General Comments
-	4 February 2014	All	Initial Release	
	28 February 2014	4-7	Added flag for non-nominal commanded state.	
	28 February 2014	Appendix	Replaced V3 of the memo with V4.	
	18 March 2014	IV.C	Added this restriction on use of Flag 14 for masking to L3.	
	June 3	All	Flag 5, 14, 16, 17, 19; Updates to Section III; Rewrite of Section IV; Improved wording	

Proposal for Flags and Masks

June 3, 2014, 2014

The following is a proposal for revising the L2 flags and masks and defining draft list of masks for transferring data from L2 to L3. The L2 masks are divided into two groups. The first group (item I below) are events for which there is either no data or a retrieval of salinity is not possible. A second set of masks proposed for the L2 calibration data where a more restrictive set of data is desired. This is given in item III below and consists of all masks in item I plus a subset of the L2 flags. These flags and masks and the thresholds are based on the recommendations of T. Meissner documented in his memo of March 18, 2014 (Aquarius: Performance Degradation and Flagging, Version 4) plus subsequent discussions at the Science Team workshop (Buenos Aires, November 12-14, 2013), telecon November 25, 2013 and Cal/Val meeting January 14, 2014.

I. Masks for Level 2:

It is proposed to adopt the following as masks for Level 2 data. They are a compilation of “quality” flags that indicate that SSS retrieval is not possible.

1. No or invalid radiometer data
2. Invalid time
3. Orbit or geolocation “out of bounds” (indicated in flag #12; indicates not earth viewing)
4. Flag #3 (mask): **rad_land_frac** > 0.5
5. Flag #4 (mask): **rad_ice_frac** > 0.5
6. Flag #13: Short accumulation overflow (from radiometer telemetry)
7. Flag #20: Radiometer instrument configuration other than nominal (OpLUT other than 0).

II. Flags for Level 2:

It is proposed to keep the current flags with the modifications listed below plus adding several new flags (i.e. for cold water; excessive reflected galactic and Moon radiation based on the first Stokes parameter and consistency of the retrieval).

A. All of existing flags (including changes indicated below)

B. New flags as follows:

1. Flag #16: Pointing Anomaly Flag: This is complementary to Flag #12 and indicates unusual operating conditions (e.g. space craft maneuver) and conditions under which the AOCS values may not be reliable:
 - a. AOCS anomaly from database
 - b. ACS mode $\neq 5$ (Indicates degraded geolocation)
2. Flag 17: Two conditions:
 - Position 1: **rad_Tb_consistency** > 0.40
 - Position 2: Emissivity = NaN; This occurs when the SSS retrieval algorithm failed due to out of bounds SST
3. Flag 18: Cold Water

Moderate: $0 \leq \text{SST} < 5 \text{ C}$

Severe: $\text{SST} < 0$

4. Flag 19: TF – TA

This is an indication of the level of RFI detected by the RFI algorithm

Large magnitude seems to correlate with large STD or bias in the salinity retrieval

Moderate: $-1.0 \text{ K} < \text{TF} - \text{TA} < -0.3 \text{ K}$ or $\text{TF} - \text{TA} > 0.3 \text{ K}$

Severe: $\text{TF} - \text{TA} < -1.00$ or $\text{TF} - \text{TA} > 0.30$

5. Flag 20: Non-nominal commanded state

This flag indicates a commanded OpLUT value other than 0 (default). This likely would only be performed for testing or anomaly investigation. The OpLUT is stored in the Level-1A product in the DPU status telemetry array.

6. Flag 21: Reflected radiation from Moon or Galaxy exceeds threshold:

Introduce new parameter: First Stokes parameter: **rad_galact_Ta_ref_I** and **rad_moon_Ta_ref_I** where $I = (\text{TV} + \text{TH})$

New flag is:

Moon: $0.5 \geq \text{rad_moon_Ta_ref_I} > 0.25$ Moderate
rad_moon_Ta_ref_I > 0.5 Severe

Galactic: (one setting):

rad_galact_Ta_ref_I > 5.6K or
rad_galact_Ta_ref_I > 3.6K and HH wind < 3 m/s

7. Flag 22: Spare

8. Flag 23: Unacceptable Asc/Dsc difference which are possibly due to undetected RFI

This flag identifies areas where the asc/dsc difference is sufficiently large that the data from the out-of-bound pass (i.e. either asc or dsc) is discarded for purposes of calibration. These data will also not be used for Level 3 processing (i.e. this is a mask for transferring data from Level 2 to Level 3). The algorithm has been provided by T. Meissner and documented in the memo in the Appendix.

C. Modifications to existing flags:

1. Flag #12: Change the limits to be consistent with proposed mask (this flag might be Eventually be redundant with Flag #16 “pointing anomaly flag”):

Roll > 1 deg

Pitch > 1 deg

Yaw > 5 deg

Out of Bounds (OOB) clat, clon = -999

2. Flag #14: Change Flag #14 to have two criteria:

Position 1: Full roughness correction not performed

Position 2: no SWH

3. Flag #5: Wind Speed (Change limits and change from NCEP to HH winds)

1. moderate $15 < \text{Rad_HH_wind_speed} \leq 20 \text{ m/s}$

2. severe **Rad_HH_wind_speed** > 20 m/s

3. did not converge: AQ wind speed retrievals did not converge for the HH and/or HHH wind speeds. Code for this flag has been provided by RSS. Failure generally corresponds to contamination by land/ice or maybe RFI.

4. No scatterometer data or scatterometer RFI flag set.

New parameter **Rad_HH_wind_speed** must be added to L2 data file: This is a derived parameter included in V3.0 of the Aquarius retrieval algorithm and derived from the scatterometer sigma_HH.

4. Flags #3 and #4 (land and ice contamination; change levels and add third level)
- Change levels from (0.005; 0.02) to (0.001; 0.01)
 - Add a third level called, “mask”: This flag will be set when ice or land fraction exceeds 0.5 (see “masks” for L2 in Section 1 above).

The revised flags are (same for **rad_land_frac** and **rad_ice_frac**):

Moderate: $0.001 < \text{rad_land_frac} \leq 0.01$

Severe: $\text{rad_land_frac} > 0.01$

Mask: $\text{rad_land_frac} > 0.5$

5. Flag #2: Not implemented in V3.0. For future versions, the rain flag is being modified to account for future MWR rain correction. The flag will have two states (flag on):

“not exist” = MWR rain retrieval not acquired; and

“moderate/severe” = MWR retrieval exists and rain rate > 0.25 mm/hr

III. Masks for L2 Calibration Data and Validation Data: In the case of the calibration data it is desired to be more restrictive. Hence, data used for calibration/validation will exclude data if any of the following conditions are met:

A. All of the L2 masks (Section I): These indicate no useful data.

B. Plus the following new L2 flags (Section II.B) will become masks. Where there is a choice (i.e. moderate or severe), and selection is not indicated, the “moderate” level is used.

- Flag #14: Full roughness correction not performed or no SWH
- Flag #12 or Flag #16: Navigation/Pointing Anomaly Flags: Mask if any flag is set
- Flag #17: **rad_Tb_consistency** > 0.40 or no SSS convergence: Note: This flag will not be available for the L2 calibration (because it requires the algorithm to be executed (i.e. a retrieval) but it should be used for validation data.
- Flag 18: Cold Water: Moderate or severe
- Flag 19: TF – TA: Moderate or severe
- Flag 20: Non-nominal commanded state
- Flag 21: Reflected radiation from Moon exceeds threshold: Moderate or severe.
- Flag 21: Reflected radiation from galaxy exceeds threshold (one setting)
- Flag 23: Unacceptable Asc/Dsc difference

C. And, in addition, eliminate extreme values of wind and land/ice contamination by adopting the following flags as masks:

1. Flags 3 and 4 (Land and Ice contamination): either moderate or severe
2. Flag 5 (wind): Any of the following
 - High wind speeds: either moderate or severe.
 - HH/HHH wind speed did not converge.
 - No scatterometer data or scatterometer RFI

IV. Masks for transferring from L2 to L3:

1. L2 masks (Section I above) are transferred to L3 (they indicate no useful data)
2. Flag #3 and #4: Land or sea ice contamination (severe)
3. Flag #5: High wind speeds (severe)
4. Flag #18: Cold SST (severe)
5. Flag #12 or Flag #16: Navigation/Pointing Anomaly Flags.
6. Flag #17: rad_Tb_consistency > 0.40 or no SSS convergence.
7. Flag 19: T-TA difference (severe)
8. Flag 21: Moon contamination (severe)
9. Flag 21: Galaxy contamination (moderate; only level)
10. Flag 23: Unacceptable Asc/Dsc differences

V. Comments and Notes

A. Flag #2: Not currently implemented. To be implemented when the MWR rain algorithm becomes available.

B. Unused Flags: The following flags have values and are implemented but are not currently used for cal/val or gridding:

1. Flag #0: RFI moderate
2. Flag #1: RFI severe
3. Flag #6: Unusual brightness temperature
4. Flag #7: Direct solar flux
5. Flag #8: Reflected solar flux
6. Flag #9: Sun glint
7. Flag #10: Moon
8. Flag #11: Reflected Galactic radiation
9. Flag #15: Solar flare

C. Previous L2→ L3 masks (Joel's masks V2 and pre-V2.6.1):

Flag 2-3 (land and ice contamination): Severe

Rad_land/ice_frac > .0.02
 Flag 6: (unusual brightness temperature): Severe
 Rad_TfX - Rad_exp_TaX > 3.0 (X = H or V)
 Flag 12 (Non-nominal navigation)
 ACS mode not 5
 |roll| > 1.0
 |pitch| > 5.0
 |yaw| > 4.0
 clat, clong out of bounds
 Flag 13 (SAoverflow)
 Radiometer overflow bit set

D. Definitions

Rad_Tb_consistency: Magnitude of the difference between the measured brightness temperature at the surface after all corrections (**rad_TBX_rc**) and the predicted values obtained using the derived SSS (not HYCOM) and a flat surface. The difference is squared, summed over both polarizations and the square root taken. However, the difference at V-pol is zero because

rad_TbV_rc is used to derive the SSS. Hence, this is the magnitude of the difference at H-pol.

rad_Tb_consistency_nolc: Same as **rad_Tb_consistency** but using the measured values before land correction (i.e. using **rad_TbX_nolc_rc**).

rad_land_frac: The gain weighted land fraction: Integration over the radiometer footprint with 1 = land and 0 = non-land (water and sea ice) weighted by the antenna pattern. Computation is made using the GSFC ODPS (SeaWiFS) 1 km resolution land mask. "Land" includes ice/snow covered land.

rad_ice_frac: The gain weighted fraction of sea ice in the radiometer footprint. The Integration is over the radiometer footprint with 0 = water and 0 = land and 1 = sea ice weighted by the antenna pattern. Computation is made using the NCEP GFS GDAS ice product: <ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/>.

rad_galact-Ta_dir_X, X = {V, H, 3}: Celestial background radiation at L-band impinging directly on the radiometer antenna. In nominal operation it enters via the antenna sidelobes (ATBD Section 2.2.1).

rad_galact-Ta_ref_X, X = {V, H, 3}: Celestial background radiation at L-band after reflection from the Earth surface. In nominal operation (i.e. pointing toward the surface) it enters primarily via the antenna mainbeam. A constant value of 3.0 K is removed and treated separately (ATBD Section 2.2.1).

rad_moon-Ta_ref_X, X = {V, H, 3}: Radiation from the Moon at polarization X after reflection from the Earth. This is important several times each month when the reflection occurs close to the footprint of the antenna main beam (ATBD Section 2.2.6).

anc_surface_temp: The surface temperature over the ocean is the NOAA OISST (Reynolds) product. Over land, the NCEP GFS GDAS product for the surface layer is used. Data is available from: ftp.emc.ncep.noaa.gov/cmb/sst/oisst_v2/YEARLY_FILES

anc_wind_speed: The wind speed from NCEP GFS GDAS at 10 m. Data is available from: <ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/>. In the L2 algorithm this NCEP GDAS wind speed is multiplied by a factor of 1.03 in order to make it consistent with observations from buoys and microwave satellites (SSM/I, WindSat).

Rad_HH_wind_speed: This is a derived parameter which is found using V3.0 of the Aquarius retrieval algorithm. It is derived using both the scatterometer sigma_HH

Rad_TaX: The difference between the antenna temperature TA before removal of RFI and after removal of RFI (i.e. TF – TA). There is one value for each radiometer and each polarization, X.

E. Appendix

Performance Degradation and Q/C Flagging of Aquarius L2 Salinity Retrievals. By Thomas Meissner, RSS, Version 4: March 18, 2014

Performance Degradation and Q/C Flagging of Aquarius L2 Salinity Retrievals

Thomas Meissner, RSS

Version 4: March 18, 2014

Objective

This memo summarizes the results of an analysis of the degradation in the Aquarius Level 2 salinity retrievals under a variety of environmental and geophysical conditions. The performance metric is SSS Aquarius – HYCOM or, equivalently, TF measured – expected. Based on the observed performance degradation we have derived threshold values for the L2 Q/C (quality control) flag. Most of the flags have a moderate (most data excluded) and a severe (less data excluded) setting. Some flags have only one setting. The conditions for the moderate/sever setting are written in a mutually exclusive way. One important guideline for the setting is to maximize the quality of the unflagged data while at the same time minimizing unnecessary data loss.

The analysis is based on RSS testbed V4.2, which is equivalent to ADPS V2.5.1.

Results for Performance Degradation

Land Contamination

gland interval		number of events	BIAS	STANDARD DEVIATION
0.00000	0.00010	22783096	0.007	0.420
0.00010	0.00020	3853818	-0.029	0.481
0.00020	0.00050	5115499	-0.061	0.484
0.00050	0.00100	3651109	0.002	0.558
0.00100	0.00200	3172253	0.034	0.658
0.00200	0.00400	2452960	-0.004	0.906
0.00400	0.00800	1180918	-0.168	1.267
0.00800	0.01200	418335	-0.395	2.123
0.01200	0.02000	455848	-0.434	2.289

Table 1: SSS Aquarius – HYCOM [psu] as function of g_{land} . The values are summed over all 3 horns. The RSS testbed Q/C flag bins: 1,2,3,4,5,6,7,8,13,14,15,18,19 were set.

Recommended threshold:

1. moderate: $0.001 \leq g_{land} < 0.01$
2. severe: $g_{land} \geq 0.010$

Sea Ice Contamination

We use the same threshold setting as for land contamination (section 0). The degradation for sea ice contamination is slightly less than for land contamination without using land correction table. However, currently we do not perform any sea ice correction in the L2 algorithm.

Lunar contamination

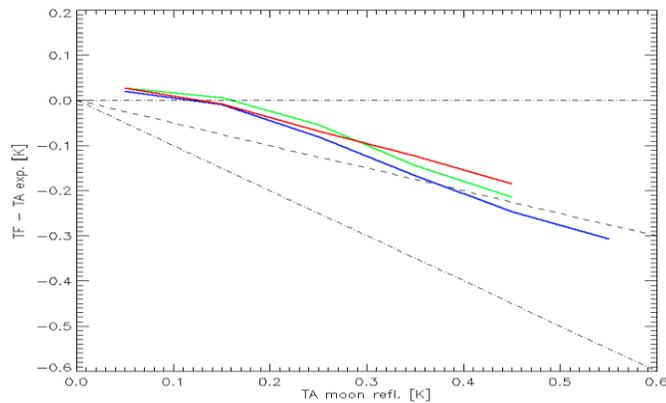


Figure 1: Bias TF measured – expected [K] as function of reflected moon TA. Blue = horn 1. Green = horn 2. Red=horn 3. The figure shows $I/2 = (V+H)/2$.

Recommended threshold:

1. moderate: $0.25 \text{ K} < \text{TA moon refl } (I=V+H) < 0.50 \text{ K}$.
2. severe: $\text{TA moon refl } (I=V+H) \geq 0.50 \text{ K}$.

T_{Berr} (Consistency)

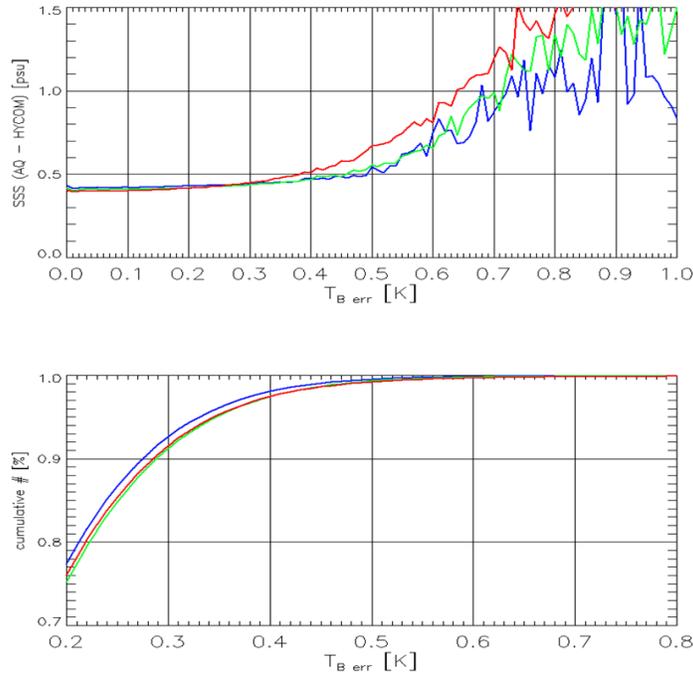


Figure 2: Upper panel: RMS of SSS Aquarius – HYCOM versus T_{Berr}. Lower panel: Cumulative histogram. Blue = horn 1. Green = horn 2. Red=horn 3.

Recommended threshold:

T_{Berr} ≥ 0.4 K. This eliminates about 2% open ocean data. We use only one setting.

Wind Speed

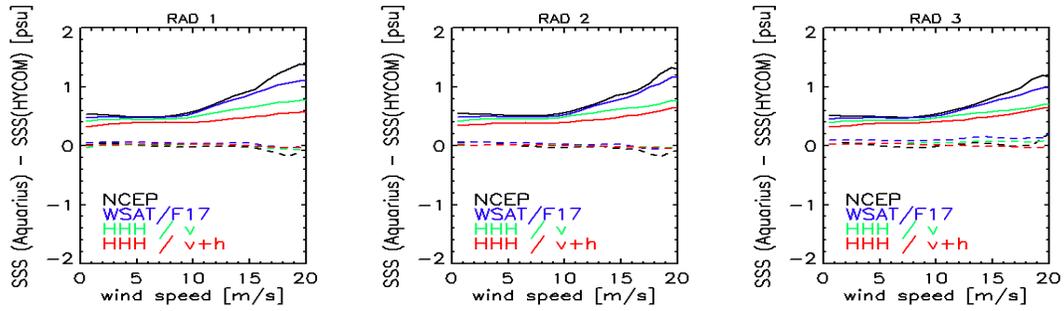


Figure 3: Aquarius – HYCOM SSS [psu] as function of wind speed that is used in the roughness correction. The red curve corresponds to RSS testbed V3 and ADPS V2.3.1. Dashed lines are biases. Full lines are standard deviations.

Recommended threshold:

1. moderate: $15 \text{ m/s} < W_{HH} < 20 \text{ m/s}$
2. severe: $W_{HH} \geq 20 \text{ m/s}$.

We note that the difference between W_{HH} and W_{HHH} is small below 20 m/s. We decide to use W_{HH} for setting the flag as W_{HHH} is not available in the calibration loop.

Sea Surface Temperature

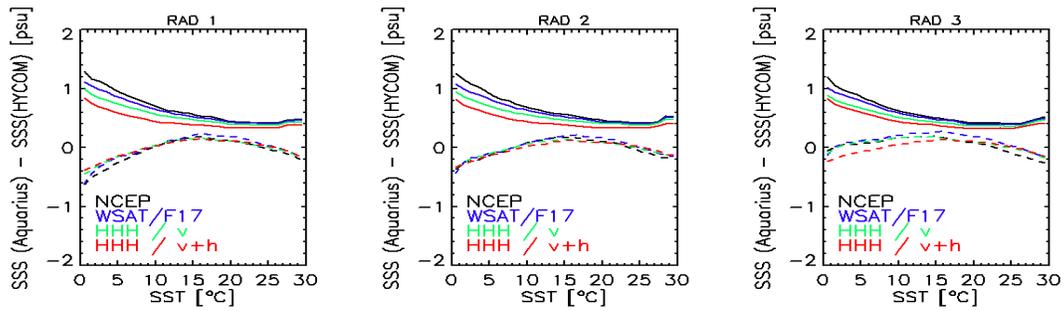


Figure 4: Aquarius – HYCOM SSS [psu] as function of SST. The red curve corresponds to RSS testbed V3 and ADPS V2.3.1. Dashed lines are biases. Full lines are standard deviations.

Recommended threshold

1. moderate: $0^\circ\text{C} \leq T_s < 5^\circ\text{C}$
2. severe: $T_s \geq 0^\circ\text{C}$

Radiometer RFI: TF – TA

TF – TA [K]	number of events	BIAS	STANDARD DEVIATION
-2.00	5664	-0.258	0.729
-1.80	7136	-0.244	0.758
-1.60	8679	-0.265	0.809
-1.40	10791	-0.246	0.763
-1.20	13398	-0.239	0.773
-1.00	18297	-0.229	0.766
-0.80	25591	-0.218	0.745
-0.60	39360	-0.204	0.733
-0.40	69955	-0.188	0.711
-0.20	689586	0.032	0.531
0.00	35365081	-0.007	0.445
0.20	380681	-0.13	0.506
0.40	479	-2.847	3.843
0.60	53	-8.065	4.029
0.80	30	-8.79	4.776
1.00	21	-10.598	5.08
1.20	12	-10.379	3.691
1.40	6	-13.354	6.611
1.60	5	-11.239	5.778
1.80	7	-12.68	4.907
2.00	1	-9.768	95.409

Table 2: SSS Aquarius – HYCOM [psu] as function of TF – TA (v-pol). The values are summed over all 3 horns. The RSS testbed Q/C flag bins: 1,2,3,4,5,6,7,9,10,11,12,13,18,19 were set.

TF – TA [K]	number of events	BIAS	STANDARD DEVIATION
-2.00	8216	-0.211	0.698

-1.80	9851	-0.199	0.684
-1.60	12034	-0.201	0.715
-1.40	14591	-0.189	0.675
-1.20	18888	-0.175	0.651
-1.00	25253	-0.179	0.683
-0.80	35574	-0.169	0.692
-0.60	55051	-0.154	0.652
-0.40	109283	-0.11	0.655
-0.20	2023028	0.045	0.487
0.00	32897189	-0.007	0.445
0.20	1391688	-0.093	0.47
0.40	7421	-0.325	0.958
0.60	128	-2.431	3.214
0.80	11	-5.384	7.387
1.00	13	-6.528	2.311
1.20	3	-5.756	0.116
1.40	3	-8.119	2.933
1.60	2	-5.599	3.052
1.80	1	-4.115	16.934
2.00	1	-12.43	154.495

Table 3: SSS Aquarius – HYCOM [psu] as function of TF – TA (h-pol). The values are summed over all 3 horns. The RSS testbed Q/C flag bins: 1,2,3,4,5,6,7,9,10,11,12,13,18,19 were set.

For regular RFI and RFI filtering TF – TA is always negative, as the filter throws out the high values within the cycle. The cases in the tables where TF – TA is positive indicates a pathological event, where the RFI is so strong and constant in time, that the RFI filter takes it as normal and discards the smaller values within the cycle. As the tables indicate, that happens extremely rarely. The RSS testbed flag 20 will likely filter out those cases. We want, however,

to flag them already right at the TA/TF level. It is very possible that those very bad events are still in the current V2.3.1 L2 files and could cause a degradation of the performance statistics.

Recommended threshold:

1. moderate: $-1.0 \text{ K} < \text{TF} - \text{TA} < -0.3 \text{ K}$ or $\text{TF} - \text{TA} > 0.3 \text{ K}$
2. severe: $\text{TF} - \text{TA} \leq -1.0 \text{ K}$ or $\text{TF} - \text{TA} > 0.3 \text{ K}$

Galactic Contamination

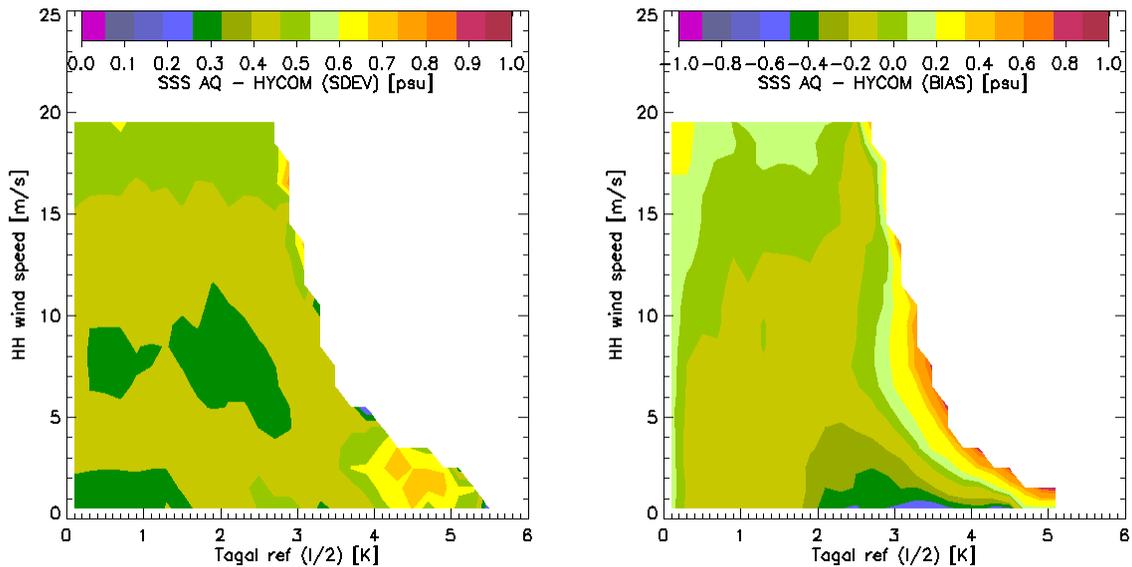


Figure 5: SSS Aquarius V2.6.1 (September 2011 – August 2013) versus HYCOM stratified by the strength of the reflected galactic radiation $(V+H)/2$ (x-axis) and HH wind speed (y-axis).
Left: Bias. Right: Standard deviation.

Recommended threshold:

Discard data if **either one** of the following conditions exists:

1. $I = V + H$ (1st Stokes) of the reflected galactic radiation exceeds 5.6 K (independent on the wind speed).
2. The wind speed is less than 3 m/s and $I = V + H$ (1st Stokes) of the reflected galactic radiation exceeds 3.6 K.

There is only 1 flag setting.

Suspected RFI Areas

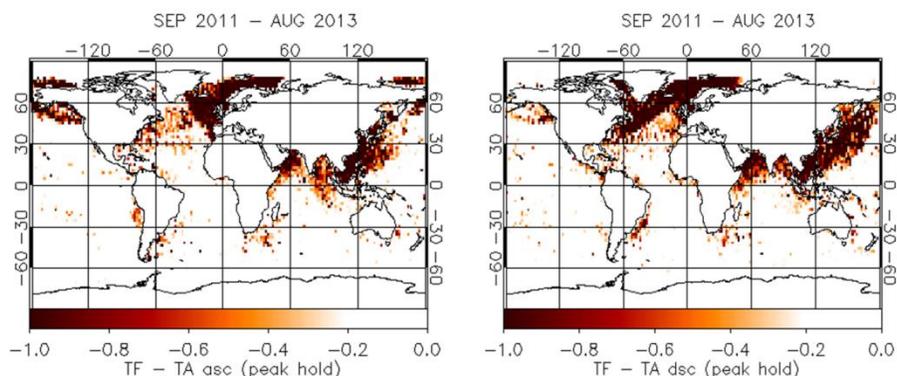


Figure 6: TF – TA peak hold maps: ascending (left), descending (right). Each map shows the minimum of the 24 monthly average values (September 2011 – August 2013) of RFI filtered (TF) minus unfiltered (TA) antenna temperatures. The resolution is 2° by 2° .

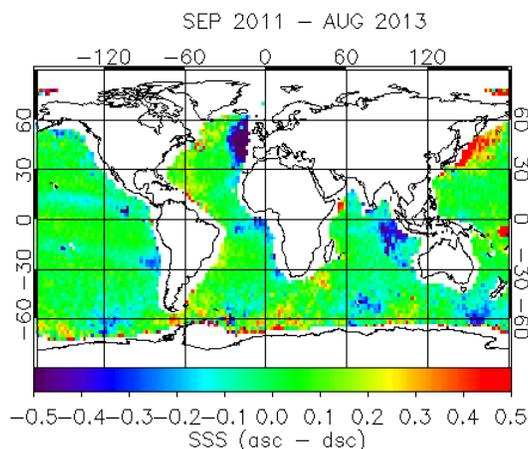


Figure 7: Observed average of ascending – descending Aquarius salinity between September 2011 – August 2013. The resolution is 2° by 2° .

The TF – TA peakhold maps (Figure 6) are a measure for the highest level of detected RFI that occur within the 24 months period September 2011 – August 2013.

The residual observed ascending – descending biases (Figure 7) indicate undetected low-level RFI in or close to many of the areas where RFI was detected.

The derivation of the L2 RFI mask is done as follows.

1. Mask 1 = Location of the TF – TA peakhold map (Figure 6) where $TF - TA < -0.3$ K.

2. Mask 2 = Extend Mask 1 by +/-4 deg. This is done as the RFI can enter through the sidelobes. Do not include pixels whose latitude is lower than 45S, as we assume that the southern oceans do not have RFI.
3. Mask 3 = Map of pixels for which SSS ascending minus descending exceeds 0.15 psu in absolute values.
4. Mask 4 = Mask 2 \cap Mask 3.
5. Optical smoothing: Fill holes and discard isolated single pixels in Mask 4. This is the final RFI mask (Figure 8).
6. Separate masks are derived separately for the ascending swath (blue) and descending swath (red).

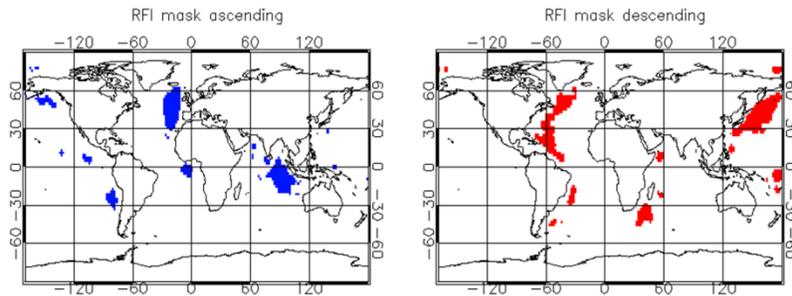


Figure 8: RFI masks: ascending (left, blue), descending (right, red). The resolution is 2° by 2°.

Recommended Use for Aquarius L2 Q/C Flags

Data should be excluded if the moderate flag setting or single flag setting applies for:

1. During the calibration loop. The exception is the Tberr/Consistency flag, which is not yet available in the calibration loop, as the SSS retrieval cannot be done.
2. Validation
3. L3 processing of the smoothed ocean product.

Q/C Flags in the RSS Testbed

RSS Testbed V6 Q/C bit	Definition in RSS Testbed V6.
0	Sparse.
1	No or invalid radiometer data.

2	No or invalid time or geolocation.
3	No or invalid scatterometer data.
4	S/C maneuver. $R/P > 1^\circ$, $Y > 5^\circ$. No boresight Earth intersection.
5	ACS mode not equal 5. Indicates degraded geolocation.
6	Bad orbit: Listed on ADPS for maneuver or anomaly.
7	Scatterometer RFI.
8	Radiometer RFI: $ TA-TF > 0.30$ Kelvin or bit overflow in radiometer counts.
9	AQ wind speed retrievals (HH and/or HHH wind speeds) did not converge.
10	Full roughness correction could not be performed: underpopulated bin in table and/or no SWH.
11	Severe land contamination: $g_{land} > 0.01$.
12	Moderate land contamination: $g_{land} > 0.001$.
13	Sea ice contamination: $g_{ice} > 0.001$.
14	High galactic radiation: [tagal ref (V+H)/2.0 > 2.8 K] OR [tagal ref (V+H)/2.0 > 1.8 K AND $W_{HH} < 3$ m/s].
15	High lunar radiation: t_{amon} ref (V+H)/2.0 > 0.125 K.
16	No MWR observation exists.
17	MWR observation exists and indicates rain (rain rate > 0.25 mm/h).
18	Cold SST: $sst = surtep - 273.15 < 5.0^\circ C$.
19	High wind speed: $winspd_{HH} > 15.0$ m/s.
20	High error or poor or no convergence in SSS retrieval $T_{berr} > 0.40$ K.
21	Observation falls within RFI mask.

Table 4: Definition of RSS Testbed V6 Q/C flag bits.